DESIGN OF AUTOMATIC COLLISION AVOIDANCE SYSTEM IN VEHICULAR NETWORKS USING FUZZY LOGIC CONTROLLER

SHORT SYNOPSIS

Submitted in partial fulfillment of the requirement of the degree of

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by

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19/Ph.D./101

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CERTIFICATE

I hereby declare that the short synopsis "Design of Automatic Collision Avoidance System in Vehicular Networks using Fuzzy Logic Controller" is being submitted in partial fulfillment of the requirement for the degreeof Doctor of Philosophy in Electronics & Communication Engineering under the faculty of Engineering & Technology of Manav Rachna International Institute of Research & Studies, Faridabad during the academic year 2022-2023. It is a bonafide record of original work carried out under the supervision of Dr. Pratima Manhas. The work has not been submitted in full or part to any other university or institute for a degree or diploma. Further, it is certified that short synopsis is plagiarism-free and the proof has been submitted.

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ABSTRACT

In today's world, there are several problems faced by us while traveling on road regarding huge congestion and collision of traffic. In order to solve this problem, there's a solution by providing autonomous vehicles that will give efficient results and are able to work without human interruption at less cost. The proposed work will determine a fuzzy logic-based controller that will control the vehicle's movement. It will create the outputs after receiving information from the Fuzzy Logic Controller (FLC) about the distance to an object, odometer, theta, ultrasonic sensor, and active sensor. Additionally, a fuzzy proportional derivative control-equipped two-wheeled self-balancing vehicle will be suggested and examined. A fuzzy proportional derivative controller is then constructed with the vehicle's position and speed as inputs, and it is utilized to govern the vehicle's angle as well as its angle rate. Finally, the vehicle's location and speed are reported. It planned an extreme control system for different self-adjusting vehicles. This platform handles autos well and performs as a better product of numerous rounds of parameter debugging. The implementation of an Adaptive Network-based FuzzyInference System (ANFIS) helps in controlling the vehicle motions using a controller. Fixed gain feedback controllers are unable to adapt to modifications in the process environment and mitigateplant parametric variations.

Keywords: Adaptive Network-based Fuzzy Inference System(ANFIS), Fuzzy Logic Controller (FLC), Neural Networks (NNs), Vehicular ad hoc network (VANET).

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1. INTRODUCTION

The concept of the autonomous vehicle has been extensively useful in the industry today. It helps to maximize safety and ensure driver convenience in terms of moving vehicles. In today's time, 95% of accidents are just due to human error. Many researchers are doing work related to the autonomous system to reduce vehicle accidents (Asljung, Nilsson and Fredriksson, 2017). Although normal vehicles provide some features to relax drivers from drowsiness, smart autonomous vehicles help to reduce accidentson roads using smart applications with the wireless system. The reason for most of the accidents is either unknown or a mistake by the opposite side. So, to handle these reasons, the autonomous concept is an emerging thing.

The use of the autonomous driver-assist system has become popular to prevent road injuries. These systems are required in India on an urgent basis as road accidents are increasing day by day. A total of 80% of accidents are due to vehicle collisions or crashes due to any reason (Dollar and Vahidi,2018). This condition is similar in all areas of the world. There are many efforts going on to improve vehicle advancement and smartness to enhance safety on roads. To solve this challenge with vehicle control, many various control techniques have been developed, including the computer torque method, optimal control, adaptive control, Variable Structure Control (VSC), NNs, and fuzzy systems. These are only some of the many different tactics that have been implemented and evaluated. The linearization of feedback is the foundation upon which torque control in a computer is built. This works as the base for the creation of torque control. Though, for putting this kind of theory into action, there's a need to have a comprehensive understanding of vehicle dynamics. With the aid of an FLC, choices about control are arrived at in line with the well-established fuzzy IF-THEN principles. FLCs can be divided into two primary categories: the first is the Mamdani-type FLC and which is used in making decisions based on fuzzy numbers; the second type is one that creates management approaches using linear combinations of the system input parameters. These two classifications can both be broken into other subcategories. A two-input FLC that applies a velocity error signal, as well as an error signal that is roughly comparable to it, is an analytical calculation to be a nonlinear fractional or Proportional-Derivative (PD) controller. Regardless of whether the controller employs an approximately equal error signal, this is the case. This is true whether the velocity error signal and the proportional error signal are used together or separately. Over the last ten years, fuzzy proportional derivative controllers have received the vast bulk of research and development attention. This is so because the most prevalent sort of fuzzy controller is the fuzzy proportional derivative controller. One aspect that leads to the

incidence of this problem is the growing use of proportional derivative controllers in industrial settings.

1.1 VANET using IoT

A vehicular ad hoc network is a network in which vehicles act as nodes and they are all dynamic, so it is called a vehicular ad-hoc network. Most vehicles use onboard sensors for leading vehicle detection now a day for avoid vehicle collisions. This is also a good initiative to enhance safety on roads. Any vehicle consists of a vehicle node, device sensor, roadside unit, and traffic management center. Some vehicles moving at a faster rate can cause concerns related to data delivery and contact crashes. Due to this, communication can affect latency performance. Figure 1 shows the movement of vehicles on the road and intersection of vehicles leveled out of roadside units.

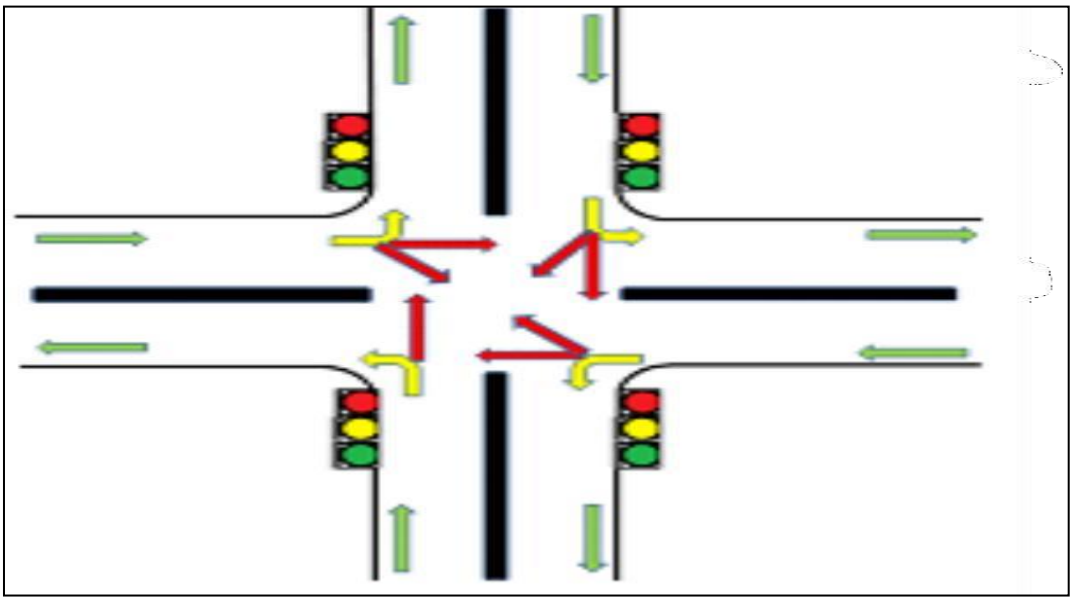

Figure 1. Vehicle Movement & Intersection on Road (Lubis and Talib 2019)

For vehicle safety, IoT can play a major role as new technology is emerging at a faster rate. It can provide solutions for the problems that occurred due to conventional reasons. When a vehicle finds an obstacle in its path, it is necessary to change the path on an immediate basis. A conventional vehicle takes a time-consuming effort to do this task but a smart vehicle with IoT can immediately detect the alternate path without obstacle and gives instruction with surrounding parameters detection to achieve the destination with less time. Similarly, in the case of multi-vehicle movements, corner collision is an issue and one of the concerns for road

accidents. Conventional vehicles depend upon streetlights and follow the path as per lights but a smart vehicle with IoT can detect alternate paths with no crowd or less crowd with the position of another vehicle on roads that can help to move easily from the lane.

1.2 Internet of Things

The IoT is a technique that involves ubiquitous participation in a network of a multitude of objects that can collaborate with one another to accomplish new goals. It defined the tangible objects or groups of such objects with sensors, processing ability, software, and other technologies in which systems and devices are connected and exchanged with other devices using networks and communication sources. It is addressable as an individual. Computational devices, digital devices, and various others for the upcoming reference are provided with unique identifiers and will also help in transferring information i.e., data without the human need or interaction between system and user. The aim of the Internet of Things is to allow technology to be linked globally using every route and service. According to a new report, demand for Megacity corridors and branded cities will increase by 2020. Despite the fact that by 2024, the overwhelming majority of people, approximately 70%, prefer to migrate to metropolitan areas. As a result, road safety and user-friendliness are deteriorating, posing a significant threat. Figure 2 shows the block diagram of components of IoT. The car industry is progressing in terms of technology. The concept of IoT is characterized by two defining features:

- Automation- This is defined as the communication between different devices.
- Connectivity- It enhanced communication between various networks on a global index scale which provides easy access to various information.

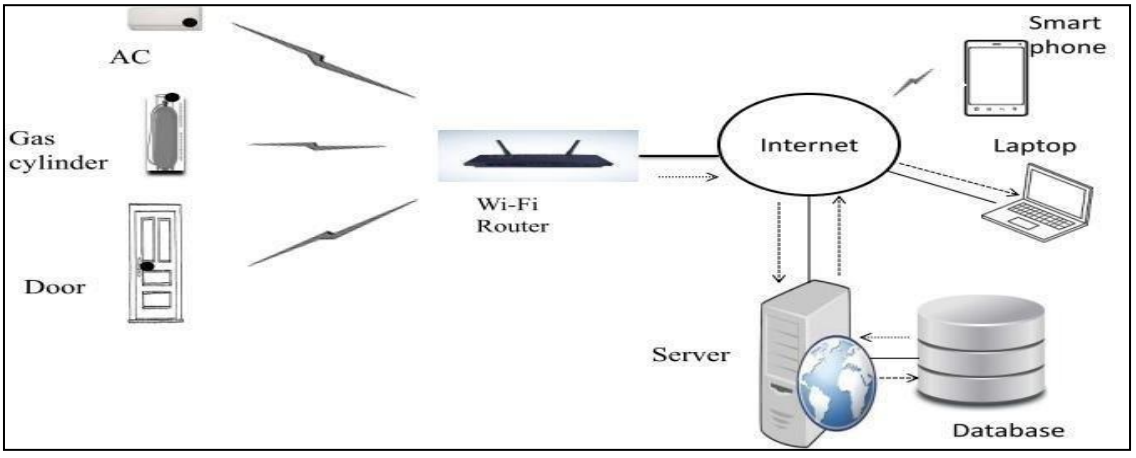

Figure 2. Block Diagram of components of IoT (Hegde and oumyalatha,2016)

The most recent automobiles have sophisticated security equipment, but they are expensive. As a result, the average person who can afford a low-end car would decline the new features such as advanced safety, voice order, wired vehicles, and so on.

Advantages

- IoT devices can access information from anywhere on any device.
- It is used to minimize human work.
- It can be used for security and safety.
- It helps with cost-effective operations.

Disadvantages

- It is highly dependent on the Internet.
- It increased unemployment rates.
- Smart vehicles are totally dependent on IoT devices.

Applications

- It can be used for smart lighting on streets or for homes.
- These devices can be used for smart parking.
- These are used for pollution monitoring and reporting.
- These devices are very useful in traffic and monitoring systems.

2. LITERATURE REVIEW

The improvement in the latest vehicle intelligence and connected vehicles with automation has taken many benefits related to road safety. It helps to reduce fuel consumption and enhance personal safety with a reduction in crash rate. Some of the research works are presented below:

Al-Heety et.al. (2020) introduced a comprehensive audit of past works by ordering them dependent on remote correspondence, especially VANET. This work likewise gave a detailed investigation of concerns and examination bearings achieved while coordinating the VANET. It provided the related study with benefits and challenges in vehicular networks.

Chen, Lu and Chu (2020) proposed an agreeable driving methodology for the associated

vehicles by coordinating vehicle speed forecast, movement arranging, and powerful fuzzy wayfollowing control.

Huang, Chen, Peng, Hu and Cao (2020) introduced a combination control system of versatile journey control and impact shirking which considers a driver's social style. It worked on a longitudinal strategy for adaptive vehicle driving style. A fusion strategy was designed to control vehicle speed. It helped to improve driver comfort.

Singhal et.al. (2020) presented artificial intelligence-enabled road vehicles and train collision assessments for railway crossings. After calculating the system performance with updated factors, it reduced the vehicle-train collision effect by 85%. Another examination objective was the impact alteration factor usage on anticipated danger factors, to diminish the street vehicle-train crash hazard at the intersections.

Yang, Wan and Qu (2020) presented the concept of forwarding collision warnings with a driver attention system. It used the module for driver attention and then system parameters were communicated to another vehicle by vehicle-to-vehicle communication. After this, it used these parametersfor reducing the risk of collision. The reproduction test results showed that the right admonition pace of the proposed framework was 97.67%. The proposed framework demonstrated the viabilityfor giving early notice to the accompanying vehicle under various driving states.

Fan et al. (2019) introduced a versatile invalid space-based conduct Null-based technique to manage the issues of immersion arranging and absence of flexibility. It worked on Null based technique for handling problems related to lack of handling concern. A platform was established as an object and verified by simulations.

Dollar and Vahidi (2018) introduced that associated mechanized vehicles utilize model prescient control for continuing in rush hour gridlock that may incorporate both hefty and traveler vehicles at semi-irregular positions. Including further authenticity, some semi arbitrarily blended vehicles are totally detached and furnished with the responsive insightful driver model utilizing pseudorandom boundaries.

Asljung, Nilsson and Fredriksson (2017) proposed that the decision of this danger measure significantly affects the deductions drawn from the information. With the correct measure, this strategy can be utilized to approve the security of a vehicle.

Funke, Brown, Erlien and Gerdes (2017) presented a control structure that integrates vehicle stabilization, path tracking and different techniques for avoiding vehicle collisions. It can even briefly abuse vehicle adjustment rules if necessary to evade a crash. The structure is executed utilizing model prescient and criticism regulators.

Han, Sciarretta, and Thibault (2017) introduced a safe-and eco-driving control framework for associated and mechanized vehicles to quicken or decelerate ideally while ensuring vehicle security limitations. At that point, a logicalstate-obliged arrangement was inferred for continuous use.

Hausler, Saccon, Aguiar, Hauser and Pascoal (2016) proposed a mathematical calculation for numerous vehicle movement arranging that expressly considers the vehicle elements. As a spurring model, they consider the situation where a gathering of vehicles is entrusted to arrive at various objective focuses simultaneously without crashing among themselves and with impediments. A maximum of people called their parents after meeting with an accident and after this, some called the helpline number 108.

Ji, Khajepour, Melek, and Huang (2017) presented the concept of optimal controlling and path planning for vehicles having automation. This was used to provide vehicle stability with a dynamic structure for handling various obstacles. It used the CARSIM tool to show the simulations among vehicles and follow the road regulations.

Rasekhipour, Khajepour, Chen and Litkouhi (2017) presented a physical layer security calculation for execution. It showed the concept of vehicle-to-vehicle propagation path at crossroads. It provided the paths scenario by using delay and dispersion as significant parameters.

Brannstrom, Coelingh, and Sjoberg (2010) proposed an algorithm related to model-based estimation for handling collisions among vehicles. It used the concept of a linear bicycle model with the vehicle as a perimeter. It was evaluated by using real-time data and situations for traffic under collision. The results were evaluated by conventional assessment and helped to reduce unwanted brake risks. This algorithm can estimate how the driver of a vehicle can either steer, brake, or accelerate to avoid accidents. This algorithm is computationally efficient and can be used to assist the driver in avoiding collisions with all types of roads.

2.1 Gaps in Literature

With reference to the various research till now, it is concluded that motion planning is necessary to generate the trajectory of a vehicle and it can be done by mapping its path. Nowadays, artificial intelligence has become a crucial part of the technology era. The use of technology provides ease in handling system problems and is very useful in vehicular networks. Various issues have been identified regarding the vehicular system and the main goal of this work is to mitigate these problems. The main gaps that come from the literature survey are:

i. Only a Forward collision avoidance system was implemented which can cause concern for safety from other sides.

ii. Vehicular safety and cost are always a concern in these networks besides the use of technology.

iii. The trajectory mapping of a vehicle is a technique that is designed to recover theparameterizations of matric ordering information of a path.

iv. It is considered only for straight roads for trajectory.

3. DESCRIPTION OF BROAD AREA

After the study of the related work of various authors, various gaps have been identified. The main concern is to handle collisions or risk-related vehicles on roads like narrow or hilly roads. This work provides the concept of trajectory mapping of vehicles on straight roads as well as on curved roads. The use of smart technology helps to identify the nearby collision with other vehicles. This work will optimize the system parameters like the velocity of the vehicle and distance from other vehicles. The focus of this work is to improve the system's reliability and also cost with the use of the latest technology. Figure 3 shows the concept of smart vehicles with lane-changing and prediction of trajectory for the movement of the vehicle on roads.

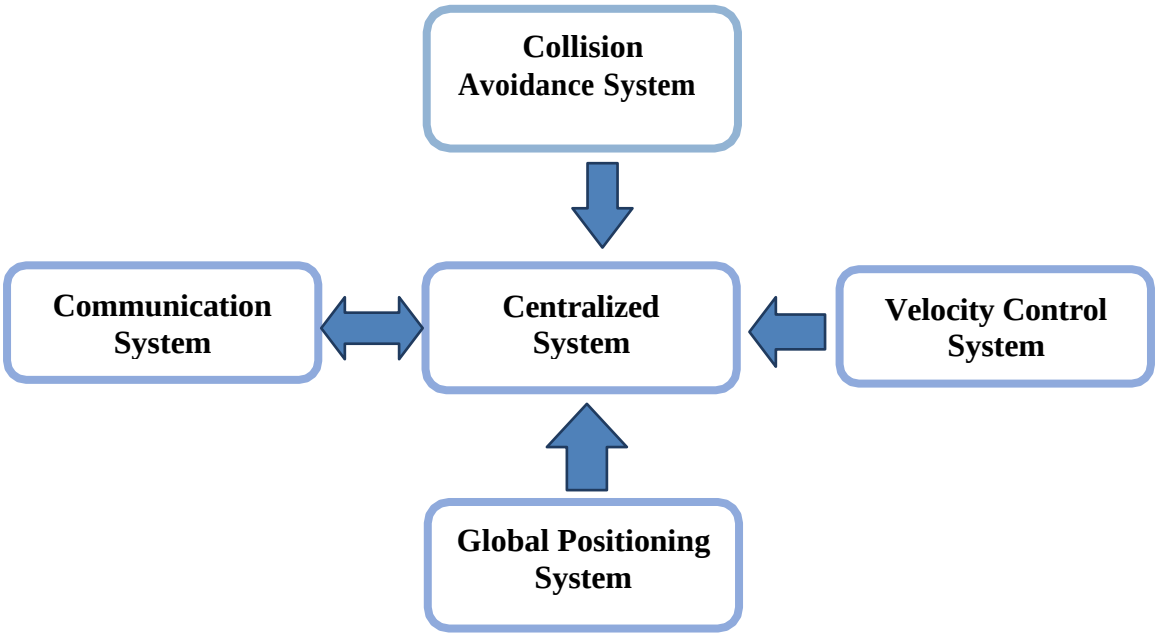

Figure 3. Block Diagram of Collision Avoidance System

A collision avoidance system is used to alert drivers to avoid the risk of accidents. It used many different technologies and sensors for avoiding collisions such as lasers, radar, artificial intelligence, and cameras. It uses the standard concept of a vehicle collision avoidance system with smart sensing and velocity control system. It will help to control system parameters with ease, which helps to reduce accidents. In India, a major concern in road accidents is vehicle collisions, so this proposed work will help to reduce vehicle collisions by use of smart sensing technology that will help to detect vehicles from the leading side also. It covers the distance between vehicles from the front and sides also so that no vehicles can collide with each other. The curved area movement is also a challenge forvehicles and reduces accidents.

3.1 Fuzzy Logic Controller

This technology is referred to by the name "Fuzzy Logic Control," which is abbreviated to FLC for short. The field of research that is concerned with the development of fuzzy set theory, fuzzy reasoning, and fuzzy logic is now the one that is seeing a much higher level of activity. FLC is useful for a very broad range of applications, some of which include the supervision ofindustrial practices, and medical equipment, in addition to safety and security measures. FLC has demonstrated that it works best when used for complex, imprecise issues that, despite the absence of previous knowledge of the societal origins of the issue, can be properly controlled by an employee controller. Due to this FLC is most effective when it is applied to problems that are difficult to manage and are not well defined. This is due to the fact that difficulties of this kind may be effectively controlled by a competent personnel controller. One of the advantages of using FLC is the way in which it can successfully manage nonlinearitywhile also operating despite having weak inputs. This is one of the perks of using FLC. In addition, the functioning is not dependent on the use of any particular mathematical model in order to perform properly. Fuzzification, aggregation, and defuzzification are typically the threeprocesses in the fuzzy logic computing process. These phases are listed in the following order: fuzzification, aggregation, and defuzzification. This list presents the procedures in the order in which they are carried out. The initial step of the procedure of fuzzification is the conversion of the numeric input variables into kernel function. One is able to notice and interpret the linguistic links that exist between the system inputs and outputs by looking at the system’s output current.

Advantages

- The Fuzzy logic system is very easy and understandable.
- The system can provide the most effective solution to complex issues.
- The system can be modified easily to improve or alter the performance.
- The system helps in dealing with engineering uncertainties.
- It is widely used for commercial and practical purposes.
- Fuzzy logic can be programmed in a situation where the feedback sensor stops working.

Applications

- These devices are used for automotive systems like vehicle environment control and automatic gearboxes.
- It can be used in domestic goods like microwave ovens, refrigerators, toasters, vacuum cleaners, washing machines, etc.
- These devices are very helpful in environmental control like air conditioners, dryers, and heaters.

3.2 Adaptive Network-Based Fuzzy Inference System

It is common to practice referring to a deep neural network as an adaptive neuro-fuzzy inference system, an adaptive network-based fuzzy inference system, or a Takagi–Sugeno fuzzy inference system. This is because the Takagi–Sugeno fuzzy inference system is used as the foundation for the construction of a deep neural network. These two names refer to the same object in different ways. There are two names for the same fuzzy inference system, yet both names refer to the same thing. The very first idea for the approach was formed in the early1990s, about the same time as work on developing it began. Even now in challenging environmental conditions, the Adaptive Network-based Fuzzy Inference System technique produces satisfactory results while simultaneously reducing computation costs, maintaining a clear structure, and optimizing its responses. Figure 4 shows the model for flow analysis in the proposed system. Applying the findings of modeling and testing to a wide range of unique operational situations to ascertain how well it would function in those circumstances confirms the capabilities of the

suggested approach. So, this work will help to reduce accidents with the useof smart sensing, and velocity control will help to control that vehicle.

Applications

- A fuzzy inference system is used in time arrangement forecasts.
- It is used in advanced mechanics.

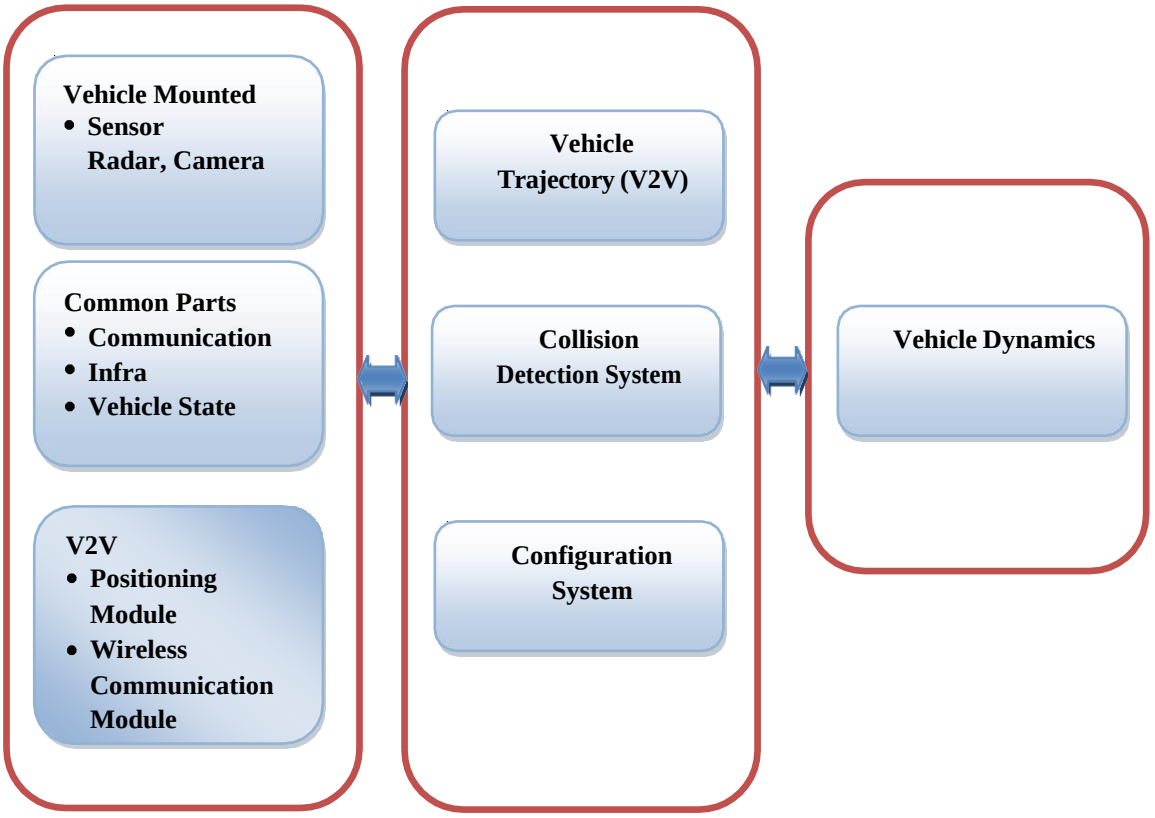

Figure 4. Model for Flow Analysis in the Proposed System

4. OBJECTIVES OF THE STUDY

A huge number of road accidents are occurring nowadays. Due to this, there's a requirement for an automatic collision avoidance system using a fuzzy logic controller to control vehicular accidents on roads. The problem and related objectives of work are described below:
The main objectives of this research shall be:

a. To do an extensive literature survey for different vehicle collision avoidance techniques.
b. To propose collision control of an autonomous two-wheeler using a fuzzy logic controller.
c. To implement an Adaptive Network-Based Fuzzy Inference System controller to control

the vehicle's movement for a collision avoidance system.

d. To compute system parameters of vehicles using a Fuzzy Logic controller.

4.2 Problem Statement

As per national highway traffic records, there are approx. 40,000 people died due to automobile collisions every year. A maximum number of people have their own vehicles and love to drive by them. Some people are experienced in driving, and some are in the learning stages. There are somereasons like human error, mechanical issues in a vehicle, outside conditions like road, and climateissues that can be a reason for automobile collisions. All drivers are concerned with ease of useand safety. Only Forward collision avoidance system consideration can cause concern for safety from other sides. Vehicular safety and cost are always a concern in these networks besides the use of technology. There is always a concern related to system parameters that are not optimized. Theconsideration of trajectory mapping of the vehicle did not consider surrounding vehicles. It considered only straight roads for trajectory but did not cover the curved or hilly area roads. Due to this, this proposed work shows the concept of an automatic collision avoidance system independent of roads or vehicles that help to handle collisions from anywhere. This would be useful for reducing human suffering from these collisions. For this, a smart technique will be useful forimplementation that will improve system reliability. i.e., Fuzzy logic controller.

5. METHODOLOGY

This proposed work uses a fuzzy logic controller to enable a two-wheeler vehicle to reach its goal without encountering any obstacles. For this, two approaches will be implemented to avoid the collision one is a fuzzy logic controller, and the second implementation is an Adaptive Network-based Fuzzy Inference System controller. Both the Fuzzy logic controller and Adaptive Network-based Fuzzy Inference System controller will be helpful for regulating vehicle movement. Various parameters will be considered for analyzing the performance. Figure 5 shows the flowchart of the proposed methodology. Fuzzy logic will be used for providing smooth results in terms of parameters. This research consists of different literature analyses for better methodology.

Step 1: The selection of techniques for avoiding vehicle collision is performed by studying the literature review of existing techniques.

Step 2: Do a selection of parameters, for example, the vehicle's location, and movement of wheels for controlling the speed of the vehicle using fuzzy logic.

Step 3: Design a collision avoidance system technique for different areas using MATLAB.
Step 4: Simulate the design and check the input and output parameters like angle and distance to the goal, odometer, theta, ultra-sonic sensor, and active sensors.
Step 5: Verify results and optimize parameters for better results.

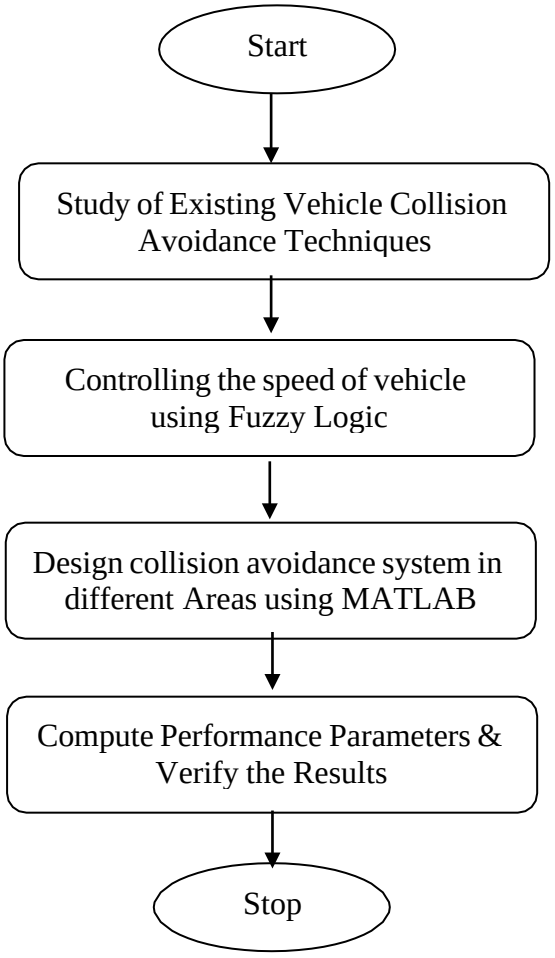
Start
Study of Existing Vehicle Collision Avoidance Techniques
Controlling the speed of vehicle using Fuzzy Logic
Design collision avoidance system in different Areas using MATLAB
Compute Performance Parameters & Verify the Results
Stop

Figure 5. Flow Chart of Methodology for Vehicle Collision Detection

6. EXPECTED OUTCOME OF RESEARCH

To reduce vehicles collision different techniques are used:

- It will provide a simulation of the control movement of autonomous two-wheeler vehicles under various scenarios like one-way traffic and two-way traffic in rural areas.
- The results will show system parameters controlled using a fuzzy controller and an adaptive network-based fuzzy inference system controller.

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DESIGN OF AUTOMATIC COLLISION AVOIDANCE SYSTEM IN VEHICULAR NETWORKS USING FUZZY LOGIC CONTROLLER

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DESIGN OF AUTOMATIC COLLISION AVOIDANCE SYSTEM IN VEHICULAR NETWORKS USING FUZZY LOGIC CONTROLLER

SHORT SYNOPSIS

by

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19/Ph.D./060

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ABSTRACT

In today's world, there are several problems faced by us while traveling on road regarding huge congestion and collision of traffic. In order to solve this problem, there's a solution by providing autonomous vehicles that will give efficient results and are able to work without human interruption at less cost. The proposed work will determine a fuzzy logic-based controller that will control the vehicle's movement. It will create the outputs after receiving information from the Fuzzy Logic Controller (FLC) about the distance to an object, odometer, theta, ultrasonic sensor, and active sensor. Additionally, a fuzzy proportional derivative control-equipped two-wheeled self-balancing vehicle will be suggested and examined. A fuzzy proportional derivative controller is then constructed with the vehicle's position and speed as inputs, and it is utilized to govern the vehicle's angle as well as its angle rate. Finally, the vehicle's location and speed are reported. It planned an extreme control system for different self-adjusting vehicles. This platform handles autos well and performs as a better product of numerous rounds of parameter debugging. The implementation of an Adaptive Network-based

Fuzzy Inference System (ANFIS) helps in controlling the vehicle motions using a controller. Fixed gain feedback controllers are unable to adapt to modifications in the process environment and mitigateplant parametric variations.

Keywords: Adaptive Network-based Fuzzy Inference System (ANFIS), Fuzzy Logic Controller (FLC), Neural Networks (NNs), Vehicular ad hoc network (VANET).

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